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Assessment of Stress and Its Impact on Eating Behavior

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Abstract

Stress is a systemic, non-specific response that an individual exhibits when responding to a stimulus and can be assessed using psychological and physiological methods. Stress not only affects eating behavior, but also indirectly affects food cravings and food choices by attenuating inhibition and rewarding activity. This study summarizes physiological and psychological stress assessment methods, and integrates the studies of chronic and acute stress on eating behavior. Subsequent studies can use more comprehensive stress assessment indicators to explore the effects of stress on the mechanisms of eating behavior. At the same time, food intake can be controlled through stress intervention in order to reduce dietary problems.

Keywords

Assessment of Stress, Eating Behavior, Cortisol, Heart Rate Variability, Reward System

应激的评估及其对进食行为的影响

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摘　要

应激是个体应对刺激时表现出的全身性非特异性反应，可使用心理学和生理学的方法进行评估。应激不仅直接影响进食行为，也通过减弱抑制和奖赏脑区活动，间接影响个体的食物渴求和食物选择。本研究梳理了前人的生理和心理应激评估方法，并整合了慢性与急性应激对进食行为影响的研究成果。未来研

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究应采用更全面的应激评估指标，以探究应激对进食行为作用机制的影响。同时，可从应激干预的角度控制食物摄入，减少饮食问题。

关键词

应激评估，进食行为，皮质醇，心率变异性，奖赏系统

1. 应激的概念、生理基础及对进食行为的意义

1.1. 应激的概念

应激(stress)又称压力，是机体应对刺激时表现出的全身性非特异性反应，当个体意识到环境要求超过他的适应能力时，应激产生。应激反应过程由生理、心理和行为多方面组成。按照作用持续时间，应激可分为急性应激和慢性应激：急性应激是指机体短时间内暴露于高强度应激源的身体内部反应，慢性应激是指在缺乏适应性应对机制的情况下，较长时间内(持续一周或更长)强烈应激源重复作用造成的身体内部反应。

1.2. 应激的生理基础

应激的生理变化涉及下丘脑－垂体－肾上腺皮质轴(hypothalamic-pituitary-adrenal axis, HPA axis)和交感－肾上腺髓质轴(Sympathetic-adrenal medulla, SAM axis) (Oken, Chamine, & Wakeland, 2015; Andrews et al., 2013)。HPA 轴是主要的内分泌应激轴，作用时间较长，应激状态时下丘脑上的室旁核促进垂体中促肾上腺皮质激素的释放(Corticotropin-releasing hormone, CRH)，后者到达肾上腺皮质，造成皮质醇等糖皮质激素的分泌(Dedovic, Duchesne, Andrews, Engert, & Pruessner, 2009)。SAM 轴反应则比较短暂，个体感受到应激源后交感神经的节前神经元被激活，使得肾上腺髓质接收到信息，肾上腺髓质和交感神经释放儿茶酚胺，引起血压升高，并将大脑对应激的感知传递到全身，从而提升个体的活动能力和效率(Aston-Jones & Cohen, 2005; Valentino & Bockstaele, 2008)。

1.3. 应激对进食的意义

应激在一定程度上能提升个体活动能力，有适应环境的价值，但过度或长期应激会造成生理失调，对个体的情绪和行为造成负面影响，其中进食行为很大程度上受到应激影响。例如研究发现长期应激暴露会造成更强的进食欲望和更多的情绪性进食(Groesz et al., 2012; Richardson, Arsenault, Cates, & Muth, 2015)。而急性应激条件下，个体的咀嚼频率增加也刺激了进食量和能量摄入的增加(Born et al., 2010; Benedict et al., 2018)。

2. 应激的评估

2.1. 量表与访谈

2.1.1. 感知压力量表

感知压力量表(The Perceived Stress Scale, PSS)是由 Cohen 编制的自评量表(Cohen, 1983)，对个体的感

知压力能力和应对能力进行评估，是衡量一个人生活压力程度的尺度。对女性的研究发现感知压力越高，情绪性进食得分越高(Tomiyama et al., 2011; Richardson et al., 2015)，对儿童、青少年和老年人的研究均发现感知压力与更多的高脂食物摄取有关(Michels et al., 2012; Hou et al., 2013; Barrington, Beresford, Mcgregor, & White, 2014)。PSS 量表是目前使用范围最广的评估主观压力的量表，在国内也是具有高应用价值的工具(刘婉婷，蚁金瑶，钟明天，&朱熊兆，2015)。

2.1.2. 社会适应评定类量表

社会适应评定量表(Social Readjustment Rating Scale, SRRS)，又称生活事件清单，量表调查被试过去 12 个月经历的应激事件，将离散的生活事件作为应激的指标进行测量，评估应激对健康的潜在影响。在医学和心理健康方面广泛使用(Monroe & Scott, 2008; Scully, Tosi, & Banning, 2000)。

研究者在探讨儿童和青少年的情绪性进食中应用了儿童生活事件量表和多维生活事件评分问卷，发现情绪状况、压力事件和进食行为之间存在正相关(Michels et al., 2012; Hou et al., 2013)，有研究使用生活事件量表发现进食美味食物能缓解消极生活事件对感知压力的影响(Finch & Tomiyama, 2015)。

2.1.3. 其他工具

特里尔慢性应激量表是对社会应激源及被试主观压力进行测量的工具(Petrowski et al., 2018; Hassoun et al., 2015)；感知应激反应性量表评估的是个体应激差异的基础——个体应激反应性，可用来揭示应激和人格等变量之间的关系(Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011; Schlotz, Phillips, & Hertfordshire Cohort Study Group, 2013; Flett et al., 2016)；职业紧张量表主要评估的是与工作有关的压力情况，适用于中文文化环境(Wu, Li, Wang, Wang, & Li, 2010)；UCLA 生活应激访谈是一种系统评价急性和慢性应激的访谈工具，主要涉及社会关系和学业问题，更适合青少年或大学生等有学业经历的群体(Cooper, Venta, & Sharp, 2018; Eames et al., 2014)。

心理测量工具更多评估的是较长一段时间内的主观压力感受，概念上更符合慢性应激的特点，不涉及应激后的客观的生理反应。当前进食行为研究中应激评估工具的选择较少，与生理学指标的联系有限。未来的进食研究可以根据被试特点使用更多适合的应激测量工具，并与生理学指标结合进行评价。

2.2. 生理学指标

2.2.1. 皮质醇浓度

皮质醇(cortisol)是糖皮质激素的一种，被称为“应激激素”，皮质醇浓度的评估本质是对 HPA 轴应激反应的评估，皮质醇的释放由下丘脑控制(Kirschbaum & Hellhammer, 1989)。一方面，应激水平越高，皮质醇分泌越多。另一方面，皮质醇水平存在个体差异，对健康群体的应激任务结果显示皮质醇具有应激反应性(Hamer & Steptoe, 2012)。

人体的体液可进行皮质醇浓度分析，其中唾液皮质醇因为简便和无创的特点更常被采用，但体液皮质醇很大程度上只能了解到个体短时间的应激水平，这与实际生活中的应激状况有差异。皮质醇水平具有时间节律，早晨起床后 30 分钟达到最高，在一天时间内逐渐下降并在睡眠时下降到最低。因此皮质醇变化斜率也成为评价应激活动的重要证据，斜率越大则说明应激活动越强(Kudielka & Kirschbaum, 2003; 聂瑞虹，许颖，&韩卓，2015)。研究者还尝试采用分时间点采集和建立潜在特征皮质醇模型等方法来反映皮质醇水平，得到皮质醇水平斜率(Stroud, Chen, Doane, & Granger, 2016)，还有研究者采集头后顶部毛发皮质醇浓度(Hair cortisol concentration, HCC)，以评估毛发生长时间段内的慢性应激水平(Stalder & Kirschbaum, 2012)。

有大量实验室研究采用特里尔社会应激测试(Trier Social Stress Test, TSST)创设应激情境后评估急性应激水平(Kirschbaum, Pirke, & Hellhammer, 1993)，皮质醇作为应激评估的“金标准”，在应激与进食的

研究中通常作为急性应激的评估指标(Strien, Roelofs, & Weerth, 2013)。有研究采集情绪性进食者的血浆皮质醇，发现女性比男性情绪性进食者有更高的皮质醇水平(Raspopow, Abizaid, Matheson, & Anisman, 2014)。也有研究采集被试的急性应激皮质醇和日间皮质醇浓度，发现皮质醇较高的女性有更高的身体质量指数(Body mass index, BMI)和更多的情绪性进食(Tomiyama, Dallman, & Epel, 2011)，还有研究在 TSST 后发现情绪性进食能缓和皮质醇反应性和进食的关系(Strien, Roelofs, & Weerth)，进一步说明皮质醇水平与情绪性进食的联系；对高皮质醇反应者进行 TSST 测试发现，烦恼次数与零食消耗量正相关(Newman, O'Connor, & Conner, 2006)；同时，在进食障碍患者中，焦虑和回避型依恋者 TSST 后会引起皮质醇分泌增加(Monteleone et al., 2019)。

2.2.2. 心率变异性

心率变异性(Heart rate variability, HRV)是连续心跳间期的变化，交感神经和副交感神经脉冲的连续变化显示出心率的变化，并造成 R－R 间期围绕其平均值振荡，应激被视为交感神经活动占主导时机体激活水平增加的状态，HRV 的检测方法包括心电图、血压和心冲击。迷走神经系统能抑制杏仁核启动的与应激有关的 HPA 轴活动，HRV 即反映迷走神经活动对心率的调节(Brown, Brosschot, Versluis, Thayer, & Verkuil, 2018; Pulopulos, Vanderhasselt, & De Raedt, 2018)。

HRV 中最常使用的分析方法分为时域分析、频率域分析和相域分析：时域分析是将时间范围内的连续 R 波峰之间的时间差(RR 间期)变异性进行统计学上的分析，主要参数有 RR 间期的标准差(SD_{RR})、相邻 RR 间期差值的均方根(RMSSD)；频率域方法是将 RR 间期变异的波纹按照频率进行分类分析的方法，主要参数有高频率(HF)、低频率(LF)以及 HF/LF 等；相域分析评估的是心率动态的质量、度量和相关特性，主要参数包括近似熵、李雅普诺夫指数、相关维数 D2 等。研究发现急性应激会降低 D2，但会增加 RR_{SD} 以及 HF 和 LF (Schubert et al., 2010)，另有研究结果显示 D2 与慢性应激负相关，急性应激会增加 RR_{SD}、HF 以及 LF (Schubert et al., 2009)，还有研究发现高 RR_{SD} 者慢性应激水平更低(Lischke et al., 2018)。

对 HRV 应激评估方法的讨论较多，主要在心理健康领域使用，在进食研究中 HRV 未被作为应激指标使用，因此在进食行为的研究上 HRV 有很大潜在价值(Vrijkotte et al., 2001; Haaren et al., 2016; Föhr et al., 2016)。

2.2.3. 其他指标

除此之外，还有其他与应激有关的生理学指标，这些客观指标从神经、心血管、内分泌和免疫系统等角度反映了应激对个体生理产生的影响，例如收缩压(systolic pressure, SBP)与舒张压(diastolic pressure, DBP)、脱氢表雄酮(Dehydroepiandrosterone, DHEA)、α 唾液淀粉酶(salivary alpha-amylase, sAA)和 C 反应蛋白(Dehydroepiandrosterone, DHEA)等，在进食与应激研究中可以拓展这类方法的应用(Vrijkotte et al., 2001; Wiernik et al., 2013; Lennartsson, Theorell, Kushnir, Bergquist, & Jonsdottir, 2013; Lennartsson, Kushnir, Bergquist, & Jonsdottir, 2012; Vineetha, Pai, Vengal, Gopalakrishna, & Narayanakurup, 2014; Johnson, Abbasi, & Master, 2013)。

2.2.4. 非稳态负荷

非稳态负荷(allostatic load, AL)是指在应激情况下重复的非稳态回应引起的耗竭，非稳态负荷理论假设生命过程中存在与应激源相关的累积生理风险，非稳态模型评估的是多个基本指标的交互作用，AL 相比单一应激指标最大的特点是能更好地预测个体的发病率和死亡率。MacArthur 是首先对 AL 进行操作性定义的人，他将 10 个指标纳入 AL，此后有研究者提出包含不同指标的 AL，并针对 AL 衍生有不同的算法规则(Juster, Mcewen, & Lupien, 2011)。

研究者利用 AL 进行了大量追踪研究，主要关注健康和社会领域。例如，双相障碍病人 AL 与死亡率的正相关(Vieta et al., 2013)，老年人高 AL 和低健康评价正相关(Read & Grundy, 2014)，老年人的疼痛程度和 AL 正相关(Sibille, Mcbeth, Smith, & Wilkie, 2016)；人格研究发现高 AL 与高神经质、低外倾性和低尽责性有关，且在四年内高 AL 者的尽责性、外向性和宜人性降低(Stephan, Sutin, Luchetti, & Terracciano, 2016)。在大脑功能和形态上，研究发现 AL 会影响海马和前额叶区域的功能和形态(Ganzel et al., 2010)，AL 甚至与脑容量和白质体积负相关，与海马体积正相关，并对认知能力产生影响(Booth et al., 2015)。

AL 主要应用在纵向研究中，强调应激累积的过程，内容集中在健康和社会环境方面，也有关于人格和大脑形态上的研究。AL 的预测作用更适合慢性应激的追踪研究，统合大量指标的评估方法使研究更为严密，有研究发现超重被试的 AL 高于健康个体(Ottino-González et al., 2019)，目前还没有关于 AL 和进食行为的研究，应激与进食行为的纵向研究中可以尝试采用该整合指标。

3. 应激、脑与进食行为的关系

3.1. 应激与进食行为的关系：生理激素的作用

进食行为是为维持能量平衡而摄入食物的行为过程，日常进食行为的目的是补充能量解决饥饿，但在非饥饿条件下，进食行为更多受应激的影响。应激促进进食行为：一方面应激打破稳态平衡造成皮质醇、胰岛素等激素的释放，影响个体的食欲和饥饿感；另一方面应激影响与新陈代谢、习惯和奖赏相关的中枢和外周调节系统，增加个体对高热量食物的渴求，从而增加个体在非饥饿状况下的进食；此外应激与负性情绪的联系也间接对情绪性进食产生影响(Dallman, 2010)。

应激通过调节激素水平从而影响生理系统，进而对进食行为和食物选择产生影响。药理学研究发现注射促肾上腺皮质释放激素的被试食物摄入更多(George, Khan, Briggs, & Abelson, 2010)，长期的糖皮质激素刺激会导致过度的进食行为和对高热量食物的渴求(Sominsky & Spencer, 2014)。应激产生的糖皮质激素能直接作用下丘脑从而影响进食行为(Newman et al., 2007)，对女性的研究发现高皮质醇反应者在应激情境下有更高的卡路里消费(Epel et al., 2001)，对暴食症患者的研究发现皮质醇水平升高时暴食和甜食渴求较正常组显著提升(Rosenberg et al., 2013)。正电子断层扫描研究发现应激事件导致腹侧纹状体多巴胺显著释放，多巴胺释放量与皮质醇对应激刺激的反应水平成正比，说明皮质醇对多巴胺释放的刺激作用(Pruessner et al., 2004)，此外下丘脑也会影响胰岛素、瘦素和生长素等激素的分泌，这些激素对大脑奖赏区域的多巴胺能传递产生影响，从而对食欲和摄食量增加起了重要作用(Raspopow et al., 2014; Adam & Epel, 2007)。

同时进食行为对应激反应具有调节作用，可缓解应激造成的生理反应。研究显示，喜好美味食物的人感知压力水平较低，感知压力与暴饮暴食症状相关(Thurston et al., 2018)。研究发现而急性应激后的情绪性进食能缓和皮质醇反应(Strien, Roelofs, & Weerth, 2013)，线索反应任务发现应激会增加个体对美味食物线索的注意，并在食物线索出现后产生强烈的食物渴求动机(Pool, Delplanque, Coppin, & Sander, 2015)。有研究认为进食能通过激活边缘区域的多巴胺活动来抑制 HPA 轴活动，美味食物的摄入能减少应激产生的生理反应，因此进食也是个体缓解应激而采用的一种策略，个体通过进食行为减少应激反应(Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015; Finch & Tomiyama, 2015)。

应激对情绪造成影响，间接促进了进食行为的产生。慢性应激者的情绪调节能力通常会减弱：研究发现有贫穷童年经历的被试在成年后，杏仁核抑制负面情绪的能力减弱，说明早期慢性应激对情绪调节能力的削弱(Kim et al., 2013)，此外磁共振成像研究发现慢性职业压力者的前扣带皮层的功能连接减弱，造成情绪调节能力减弱(Golkar et al., 2014)，研究还发现情绪调节能力与暴食等进食障碍症状负相关(Prefit, Cândea, & Tătar, 2019)。应激造成个体对负面情绪的调节能力减弱，从而对进食行为产生影响，研究发现，具有负

面情绪的限制性饮食者会通过增加进食来进行应对(Evers, Dingemans, Junghans, & Boev'e, 2018)。这些研究说明应激通过情绪调节能力，不仅对进食行为产生影响，甚至与进食障碍也有联系。

3.2. 应激与进食行为的关系：奖赏与抑制脑区的作用

应激减弱抑制能力，从而影响进食行为(Cassandra, Amy, & Peter, 2019; Girotti, Adler, Bulin, Fucich, & Morilak, 2018)。抑制控制是前额叶的重要功能，经颅直流电刺激研究发现对前额叶区域的刺激能影响抑制控制的强弱(Cavanagh & Frank, 2014; Hsu et al., 2011)，研究发现 go/no go 食物反应抑制训练减少了零食的消耗，说明抑制控制能力对进食行为的影响(Bartholdy, Campbel, Schmidt, & O'Daly, 2016; Oomen, Grol, Spronk, Booth, & Fox, 2018)。应激对前额叶活动的抑制作用显著，持续应激会造成儿茶酚胺的释放，造成前额叶功能的持续削弱(Arnsten, 2015)。应激则通过对前额叶功能的改变影响进食行为：急性应激易感个体的前额叶对价值信号的控制减弱，造成对食物线索的反应性增强，食物选择过程中的冲动性增加，使个体更容易选择美味高热量食物(Maier, Makwana, & Hare, 2015)。相反成功抑制进食行为的个体则具有更易被激活的额下回功能，抑制进食冲动的能力更强。对女性成功限制性饮食者的核磁研究也发现，当面对食物线索时，负责抑制控制的额下回更易被激活(Lopez et al., 2016)，这一结论在抑制控制缺陷与非健康饮食相关的调查结果中也有印证(Jasinska et al., 2012)。此外元分析研究发现在进食控制研究中，BMI 指数与背外侧前额叶皮质活动负相关，与脑岛中部和前脑岛活动正相关(Han, Boachie, Garcia, Michaud, & Dagher, 2018)，有关食物线索的经颅磁刺激研究发现背外侧前额叶皮质在高热量食物的注意资源调节上作用明显，因此应激通过减弱抑制作用，对食物选择产生影响(Cassandra et al., 2018)。

奖赏系统是边缘系统、前额叶、纹状体和中脑区域组成的一个区域网络。进食能够在一定程度上调节应激对机体内部产生的不平衡状态，这一调节主要是通过对奖赏系统的影响而产生的(Dallman, 2010)。研究发现人类在愉悦进食和食用高糖高脂食物后纹状体会释放多巴胺(Wang, Geliebter, Volkow, Telang, & Fowler, 2011)，大脑奖赏系统的激活可以减弱对各种应激源的反应，边缘和前脑奖赏系统可以调节应激反应水平(Dutcher & Creswell, 2018)。奖赏系统的多巴胺和内源性阿片肽能够对应激进行调节：多巴胺的释放能防止过度的生理应激反应和行为，分布于杏仁核和下丘脑在内的边缘系统的内源性阿片肽能减弱对情绪的反应，从而减少应激的影响。

高度和重复应激会改变前额叶和边缘区域的结构和功能反应，影响了大脑食物奖赏和食物渴求(Sinha & Jastreboff, 2013)。主要表现在应激会造成奖赏激活降低，促使个体更多寻求进食奖赏，增加能量的摄入。通过概率刺激选择任务发现急性应激下的个体对奖赏的反应性降低(Berghorst, Ryan, Frank, & Pizzagalli, 2013)，对女性的研究发现急性应激会减少大脑奖赏区的杏仁核、海马和扣带回皮层活动(Born et al., 2010)，对男性的研究发现急性应激刺激会促进个体对奖赏的追求，这种奖赏刺激可以是关于性的，也可以是食欲相关的(Kruse et al., 2018; Creswell, Pacilio, Denson, & Satyshur, 2013)。对青少年的研究发现应激和食物线索处理中共用了纹状体和丘脑区域，纹状体活动减弱可能成为进行补偿性应激和奖赏性饮食的驱动力(Hommer, Seo, Lacadie, Chaplin, & Potenza, 2013)。自我报告压力显著增加的暴食症女性前扣带回皮层、楔前叶和背外侧前额叶皮层激活减弱，普遍表现出在应激下食物线索的神经反应增强(Fischer et al., 2017)。有研究发现急性应激造成女性内侧前额叶皮质的奖赏相关反应显著降低，不仅如此，应激有关的奖赏行为问题可能与前额叶认知控制的损害有关(Ossewaarde et al., 2011)。这些研究说明，应激减弱了奖赏系统的激活，增加个体对食物奖赏的渴求，并显著增加进食行为。

4. 总结和展望

首先，与进食有关的慢性应激研究多在自然环境下进行，使用 PSS 和各类生活事件量表为主的测量

工具，偏重于被试的主观体验和感受，急性应激研究多在实验室环境下进行，使用以皮质醇为主的生理学指标，偏重于与应激作用机制有关的内分泌、神经系统和免疫系统的变化，因此研究中同时存在生态效度和客观性两类问题。此外当前研究发现，两类评估方法在结果上并不完全一致，例如低社会经济地位的女性和公务员的研究均发现皮质醇水平与感知压力量表无关(Olstad et al., 2016; Mikkelsen et al., 2017)，对成年人的研究发现高职位群体感知压力与收缩压负相关，低职位群体则相反(Wiernik et al., 2015)。这些研究说明应激评估方法的多样和评估角度各异，但评估结果的一致性较低，因此未来研究中需要将心理工具和生理指标评估方法结合使用，以保证研究结果的准确全面。在进食研究中对两类应激结果尤其是慢性应激水平都予以参考，对于可以得到慢性应激结果的部分生理指标，如毛发皮质醇、HRV 指数，应增加它们在进食行为研究上的应用(Stalder & Kirschbaum, 2012)，并在进食行为研究中加入慢性应激水平的量表测量。这些方法可以推动生理心理学在心理学上的交叉研究，丰富心理学的研究方法。

其次，有研究发现只在低慢性应激者中，高急性应激反应性的女性摄入食物更少，说明慢性应激会对急性应激下的进食行为产生影响(Klatzkin, Baldassaro, & Hayden, 2018)。未来研究需要更多急性应激和慢性应激评估方法的同时使用，例如使用量表和访谈工具以及部分生理指标评估个体的慢性应激水平，创设急性应激情境研究应激与进食的关系，不同应激类型对进食的影响有其差异性，在研究中应综合考虑两种应激类型对进食行为的影响。

另外，目前进食研究中的应激指标以皮质醇为主，未来研究可将 HRV、sAA 等被证实有评估价值的指标引入应激有关的进食行为研究，发挥它们在评估和干预中的作用，增强研究的客观性；AL 在健康领域的研究较为广泛，已有研究证明超重被试的 AL 高于健康群体(Ottino-González et al., 2019)，而进食行为与体重的关系密切。因此 AL 这一整合生理指标可作为跟踪个体长期进食行为的应激指标，在未来的研究中发挥作用。

最后，应激是造成进食问题的重要因素，对应激的干预可以改善进食行为。对青少年的研究发现生活压力和饮食行为量表正相关，说明对应激的一定干预可以减少不良进食行为(Hou et al., 2013)。目前应用较多的干预方法包括运动、正念和瑜伽，对学生的研究发现为期 20 周的有氧训练能降低 HRV 应激指标，说明运动对应激反应的缓解作用(Haaren et al., 2016)，正念能缓解应激水平，并且表现在与应激有关的血压、皮质醇、CRP 等指标上(Reive, 2019)，研究发现瑜伽练习能通过影响个体应对应激源的方式来降低应激，同时瑜伽能降低与应激有关的皮质醇、HRV、血压等指标(Pascoe et al., 2017; Francis & Beemer, 2019)。但目前研究中的应激干预方法并没有与进食行为结合起来，也没有研究利用生理和心理指标验证应激干预对进食的影响，未来研究可以探索饮食行为的应激干预方法，通过应激干预达到减少不必要进食的目的。同时，进食行为是机体减少应激的一种奖赏策略，奖赏系统的激活可以减少应激反应水平(Dutcher & Creswell, 2018)，未来研究可以尝试通过其他类型的奖赏刺激(如自我肯定、正性回忆、社会支持)代替进食行为，对应激反应进行干预，从而降低个体通过食物奖赏来缓解应激的行为，减少进食和由此产生的肥胖问题。

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